

PATENT COOPERATION TREATY
PCT
INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter II of the Patent Cooperation Treaty)
(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P22749PCAU	FOR FURTHER ACTION		See Form PCT/IPEA/416
International application No. PCT/AU2004/000926	International filing date (<i>day/month/year</i>) 9 July 2004	Priority date (<i>day/month/year</i>) 9 July 2003	
International Patent Classification (IPC) or national classification and IPC Int. Cl. ⁷ F28D 5/00, F24F 3/06, 11/06, F28C 3/06, 3/08			
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<p>1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.</p> <p>2. This REPORT consists of a total of 3 sheets, including this cover sheet.</p> <p>3. This report is also accompanied by ANNEXES, comprising:</p> <p style="margin-left: 20px;">a. <input checked="" type="checkbox"/> (<i>sent to the applicant and to the International Bureau</i>) a total of 7 sheets, as follows:</p> <div style="margin-left: 40px;"> <p><input type="checkbox"/> sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).</p> <p><input type="checkbox"/> sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.</p> </div> <p style="margin-left: 20px;">b. <input type="checkbox"/> (<i>sent to the International Bureau only</i>) a total of (indicate type and number of electronic carrier(s)) _____, containing a sequence listing and/or table related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).</p> <p>4. This report contains indications relating to the following items:</p> <div style="margin-left: 20px;"> <p><input checked="" type="checkbox"/> Box No. I Basis of the report</p> <p><input type="checkbox"/> Box No. II Priority</p> <p><input type="checkbox"/> Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability</p> <p><input type="checkbox"/> Box No. IV Lack of unity of invention</p> <p><input checked="" type="checkbox"/> Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement</p> <p><input type="checkbox"/> Box No. VI Certain documents cited</p> <p><input type="checkbox"/> Box No. VII Certain defects in the international application</p> <p><input type="checkbox"/> Box No. VIII Certain observations on the international application</p> </div>	
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Date of submission of the demand 9 May 2005	Date of completion of the report 14 October 2005
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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/AU2004/000926

Box No. I Basis of the report

1. With regard to the language, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ This report is based on translations from the original language into the following language which is the language of a translation furnished for the purposes of:

☐ international search (under Rules 12.3 and 23.1 (b))

☐ publication of the international application (under Rule 12.4)

☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the elements of the international application, this report is based on (*replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report*):

☐ the international application as originally filed/furnished

☒ the description: pages 2, 4, 6, 8, 9, 12-23 as originally filed/furnished
pages 1, 3, 5, 7, 10, 11 received by this Authority on 24 May 2005 with the letter of 17 May 2005
pages , received by this Authority on with the letter of

☒ the claims: pages 24-27 as originally filed/furnished
pages , as amended (together with any statement) under Article 19,
page 28 , received by this Authority on 9 May 2005 with the letter of the same
pages , received by this Authority on with the letter of

☒ the drawings: pages 1-4 as originally filed/furnished
pages , received by this Authority on with the letter of
pages , received by this Authority on with the letter of

☐ a sequence listing and/or any related table(s) - see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages

☐ the claims, Nos.

☐ the drawings, sheets/figs

☐ the sequence listing (*specify*):

☐ any table(s) related to the sequence listing (*specify*):

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

☐ the description, pages

☐ the claims, Nos.

☐ the drawings, sheets/figs

☐ the sequence listing (*specify*):

☐ any table(s) related to the sequence listing (*specify*):

* If item 4 applies, some or all of those sheets may be marked "superseded."

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.

PCT/AU2004/000926

Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	YES
	Claims 1-28	NO
Inventive step (IS)	Claims	YES
	Claims 1-28	NO
Industrial applicability (IA)	Claims 1-28	YES
	Claims	NO

2. Citations and explanations (Rule 70.7)

- D1: GB 2378501 A (URE) 12 February 2003, Abstract, Page 4 paragraphs 2-3, Figure 4
D2: WO 2003/006908 A (MULLER INDUSTRIES) 23 January 2003, Whole Document
D3: US 2655795 A (DYER) 20 October 1953, Claim 1
D4: US 4182131 A (MARSHALL et al) 8 January 1980, Column 5 lines 16-23, Figure 8
D5: Derwent Abstract Accession No. 2003-252827/25, JP 2003065561 A (YOKOGAWA DENKI) 5 March 2003
D6: EP 402131 A (BALTIMORE AIRCOIL) 12 December 1990, Column 5 line 57 to column 6 line 3
D7: US 6253565 B (ARLEDGE) 3 July 2001, Whole Document
D8: US 6141986 A (KOPLIN) 7 November 2000, Abstract and Figure 3
D9: EP 927326 B (DEUTSCHES ZENTRUM FUR LUFT) 22 November 2000, Claims and Figure 1
D10: US 20030145619 A (WORD) 7 August 2003, Abstract

Novelty

D1 discloses a cooling unit wherein water is sprayed onto a wire mesh through which air flows. The water spray is located between the wire mesh and the heat exchanger. The cooled air then cools the heat exchanger. The unit may be operated intermittently, eg in peak periods, either by using a sensor measuring the ambient temperature, or by using a pressure sensor measuring the pressure of the refrigerant in the condenser. Therefore, claim 1 at least is not novel. The features defined in the other claims are either disclosed in D1 or are features that cannot be considered to involve an inventive step.

The applicant argues that the present claims are novel over D1 because in D1 the liquid is sprayed onto the mesh rather than directly onto the heat exchanger as in the present invention. However, it is noted that the independent claims at least, of the present application, merely define that the liquid is dispensed *into the forced air*. This is what happens in D1 (although it is dispensed in the opposite direction).

Inventive Step

D2-D4 disclose cooling units wherein the air is cooled by passing it through a moist pad and then blowing the cooled air against the heat exchanger.

D5-D9 disclose cooling units wherein water is sprayed into an air stream, thereby cooling it, and then blowing it against the heat exchanger.

It is not considered obvious to combine these documents in order to minimise depositing the liquid directly onto the heat exchanger to reduce the deposition of contaminants. Therefore, the claims are inventive over D2-D9.

SYSTEM AND METHOD OF COOLING

FIELD OF THE INVENTION

The system and method of the present invention relates generally to the cooling of air and more particularly to a system and method of cooling air in systems including a heat exchange unit to effect heat transfer from a cooling fluid. The invention is particularly suited to cooling systems for relatively large volumes of air which is required in circumstances such as the cooling of air in large office buildings.

BACKGROUND OF THE INVENTION

Areas occupied by people generally require some form of heating and/or cooling in order to maintain the area at a reasonable temperature. In some instances, statutory or contractual arrangements require an area or premises to be maintained within certain temperature limits.

Accordingly, heating and cooling systems have developed over time and exist in most modern premises in order to maintain the temperature in those premises within predetermined temperature limits.

Heating and cooling large areas such as an office building usually requires a significant capital investment in the plant and equipment that effects the heating and/or cooling.

In warm climates, cooling systems incorporating a cooling tower have become a popular type of system for the cooling of large buildings. In this type of system, a refrigerant gas is used to cool air as it passes through a first heat exchange unit (evaporator) and having absorbed energy from the air, the refrigerant gas is passed to a second heat exchange unit (condenser) wherein heat is extracted from the refrigerant gas. The second heat exchange unit is supplied with water to effect cooling of the refrigerant gas and having absorbed energy, the water is generally transferred to a third heat exchange unit (cooling tower) in order to cool the water in preparation for further use. Whilst this type of system is commonly used for large office buildings, cooling towers unfortunately provide an environment conducive to the generation and distribution of a bacterium known as *legionella pneumophila*. The bacterium becomes airborne and subsequent inhalation by people in the vicinity of a cooling tower may lead to the development of a disease commonly referred to Legionnaires' Disease.

been limited to an acceptable level in addition to any chemical treatment. Apart from the cost of the biocides, the requirement for ongoing sampling has the effect of significantly increasing the maintenance cost for a cooling tower system.

5 The use of ozone has also been proposed and has been successfully used
in some instances to reduce microbial growth. Although ozone is an unstable
chemical, it is a powerful oxidising biocide and must be produced on-site by
means of an ozone generator and used immediately for water treatment. Ozone
disinfection is relatively new for the control of bacterial levels in cooling tower
waters and it is generally recognised that care must be exercised to maintain
10 generators in accordance with manufacturer's recommendations thus ensuring
optimum efficiency. Apart from the significant capital investment required for an
ozone generator, there remains some doubt as to the efficacy of this type of
system for preventing microbial growth and the spread of Legionnaires' Disease.

The use of ultraviolet light has also been proposed for the reduction of
15 bacterial levels in cooling tower water. With these types of systems, the cooling
tower water is exposed to ultraviolet radiation of a sufficient intensity to eliminate
bacterium in the water. It is important to ensure that the water is exposed to a
sufficient level of ultraviolet radiation intensity for the system to be effective.
Sensors are generally used to monitor the intensity of the ultraviolet radiation and
20 any reduction in efficacy as detected by the sensors generally provides an
indication that maintenance is required. Ultraviolet radiation has no effect on the
pH, odour or chemical composition of cooling tower water. However, the colour,
tepidity and chemical composition of the water can interfere with ultraviolet
radiation transmission and as such, determination of the ultraviolet absorbency of
25 the water to be treated prior to installing ultraviolet equipment is usually
advisable. Bacteria may be protected by tepidity, clumping or the presence of
slime and accordingly, appropriate water filtration is usually recommended in
conjunction with ultraviolet radiation systems.

Despite implementing such a system to destroy bacterium, the ultraviolet
30 damage to bacterium can be significantly reversed by enzyme repair mechanisms
such as those that operate in darkness and on subsequent exposure to bright
light (photoreactivation). Once again, the installation of an ultraviolet radiation

Whilst this arrangement included a closed circuit for cooling fluid to eliminate the possibility of the cooling system generating air borne *legionella pneumophila*, it was subsequently discovered that this arrangement suffered from a much reduced cooling capacity as compared with a cooling system of similar size operating in accordance with previously known solutions that included an open circuit for the cooling fluid.

In order to achieve the same cooling capacity as a prior art system, it was necessary to produce a significantly physically larger apparatus comprising a pre-cooler and closed circuit heat exchanger for cooling fluid.

The problem of reduced cooling capacity for an apparatus comprising a pre-cooler with a closed circuit heat exchanger is a substantial problem given that building management operators usually seek to replace or convert their existing open loop heat exchangers in order to eliminate the risk that their present cooling systems cause the generation of air borne *legionella pneumophila*. In a large number of existing installations, the physical space available on a rooftop is limited and it is not possible to replace an existing open loop heat exchanger with a much larger closed loop heat exchanger arrangement. Further, there is a significant increase in the capital cost of an apparatus of this type with increased physical size.

However, the requirement for a cooling system to accommodate a particular cooling capacity is usually based upon the worst case conditions where the building is subject to a heat load that occurs during the summer period. In particular, it is not unusual for the maximum cooling capacity to only be required for approximately 15 to 20 days during any 365 day period.

Accordingly, it is an object of the present invention to provide a cooling system, and method of cooling, including a primary heat exchange unit having a closed circuit for cooling fluid with an air cooler located upstream of the primary heat exchanger and a fan arrangement for forcing air through the cooler and the primary heat exchanger with an improved cooling capacity as compared with previously disclosed systems of this type.

Any discussion of documents, acts, materials, devices, articles or the like which has been included in the present specification is solely for the purpose of providing a context for the present invention. It is not to be taken as an admission

exchanger for a particular thermal load. Accordingly, the present invention is also useful in situations where cooling fluid other than water is used such as refrigerant.

Operation of the liquid dispenser improves the cooling capacity of the cooling fluid heat exchanger as compared with relying only upon the passing of forced cooled air over portions of the primary heat exchanger. As operation of the liquid dispenser has the potential disadvantage of leaving contaminant deposits on the primary heat exchanger (which can have the subsequent effect of reducing the heat exchange performance of the unit) the liquid dispenser is preferably only operated during periods in which a greater cooling capacity is required from the cooling fluid heat exchanger. However, in a further embodiment the liquid dispenser can also be used to permit washing of an external surface of the primary heat exchanger. Washing of the primary heat exchanger reduces the amount of dust and dirt which can accumulate on the surfaces of the primary heat exchanger. Operation of the liquid dispenser to implement washing can be effected automatically at predetermined periodic intervals, and assists to maintain the thermal transfer performance of a heat exchanger.

Of course, it is preferable to use a liquid that is inexpensive and in plentiful supply. In a particularly preferred embodiment, the liquid used for dispensing is the mains supplied drinking water. However, this water usually contains contaminants that are in solution, such as calcium, that are very difficult to remove from the water. Filtration techniques that effectively remove contaminants that are "in solution" from water are generally quite expensive and are therefore usually considered economically infeasible. When mains supplied water is applied to a closed circuit cooling heat exchanger, subsequent to evaporation of the water, the calcium and other contaminants are usually left as deposits on the heat exchanger. The remaining deposits can prevent air flow over portions of the closed circuit heat exchanger and hence reduce the cooling efficiency of the unit. Eventually, heat exchangers will require maintenance to remove a build up of contaminant deposits in order to restore the unit to its original efficiency.

Accordingly, minimal use of dispensed liquid reduces the rate at which contaminants are deposited on the heat exchanger and hence reduces the rate at

The air cooler may be located over the plurality of air inlets such that air drawn through the air cooler by the fan arrangement is cooled prior to being drawn or forced over the primary heat exchanger and subsequently through the plurality of air outlets.

5 Where the cooling fluid is water, the cooling water preferably passes through the primary heat exchanger in thermally conductive tubing, such as copper tubing, with drawn air passing over the tubing and removing thermal energy from the water passing through that tubing.

10 The air cooler preferably includes a water absorbent material similar to that used in evaporative cooling applications and may include wood fibre or cooling pad material such as that distributed under the trade mark "CELDEK". The moistened water absorbent material cools air passing through the material by the action of evaporation. This effect is used generally in evaporative cooling systems and water, separate from the cooling fluid, may be supplied to the water
15 absorbent material using apparatus similar to that in current evaporative cooling systems.

20 Water is the preferred liquid to be dispensed and the depositing of water onto the primary heat exchanger does not pose any risk of generating or distributing air borne *legionella pneumophila* as the water temperature would not rise to a sufficient level to present a risk.

The additional cooling effect of dispensing liquid into the forced air downstream from the air cooler yet upstream from the heat exchanger occurs as a result of various contributing effects:

25 Firstly, the dispensing of liquid into the air stream subsequent to the air cooler has the effect of increasing the saturation efficiency of the air cooler. For example, whilst the air cooler may have a saturation efficiency of 70 – 80%, the dispensed liquid may result in an increased saturation of greater than 80% which has the effect of reducing the dry bulb temperature of the forced air further as compared with the temperature of the air emitted from the air cooler.

30 Secondly, in the instance where dispensed liquid impinges upon the surface of the primary heat exchanger, there is a natural effect of thermodynamics wherein all bodies in thermally conductive contact with each other attempt to reach thermal equilibrium. In this instance, depositing relatively

cool dispensed liquid onto the surface of a relatively hot closed circuit heat exchanger will cause thermal energy to be removed from the heat exchanger and cause the temperature of the deposited liquid to rise. If the temperature rise of the deposited liquid is sufficient, the liquid may change state from its liquid state to a gaseous state.

Thirdly, the forcing of air through the heat exchanger and over the portions of the closed circuit heat exchanger that have liquid deposited onto them, reduces the vapourisation pressure of the liquid (i.e. the air pressure at which the liquid will change state from a liquid to a gas). A reduction in the vapourisation pressure increases the likelihood that deposited liquid will vapourise and hence increases the rate at which thermal energy will be extracted from the heat exchanger in order to enable the liquid to change state.

Generally, pads of water absorbent material would be located substantially vertically over the air inlets of the heat exchanger and water would be applied to an upper portion of the water absorbent pads and would migrate downwardly through and moisten the entire pad. In the event that water is applied to the absorbent material pad at a rate faster than evaporation therefrom, a holding tank may be suspended below the material pads in order to collect water run-off. Any water run-off collected in a tank may be reused by pumping that water back to the upper portion of the material pads for reapplication thereto.

In a particularly preferred embodiment, a water absorbent material pad including a plurality of fluted apertures of a size less than 7mm is used as part of the air cooler. Ordinarily in evaporative cooling applications, a water absorbent material pad with a plurality of 7mm fluted apertures is used. However, in this embodiment of the invention, use of a pad with fluted apertures of a size less than the standard size of 7mm has been found to provide a more efficient cooling effect. This particular embodiment also uses variable pitch fans for drawing air through the primary heat exchanger and through the air cooler pads. As a result of the increased efficiency resulting from the use of a pad with fluted apertures less than 7mm, the overall pad size may be reduced whilst still achieving the same cooling effect of a pad with standard sized fluted apertures. A reduction in the overall size of an air cooler pad may be significant for installations where a conversion from an existing cooling tower arrangement is required and

air forced through said cooler is cooled prior to being forced over a portion of said closed circuit in said primary heat exchanger.

27. A method of cooling fluid in a cooling fluid heat exchanger, the method including the steps of:

- 5 passing cooling fluid of a cooling system through a primary heat exchanger having a closed fluid circuit such that the cooling fluid is contained;
 - locating an air cooler upstream of the primary heat exchanger and a liquid dispenser downstream of the air cooler; and
 - 10 forcing a flow of air through the air cooler thus generating a forced air stream that is directed over a portion of the closed fluid circuit wherein said air cooler includes a moisture absorbent material that is, in use, maintained moist such that the air passing through the moisture absorbent material is cooled by vaporising the fluid contained therein and operating the liquid dispenser to dispense liquid into the forced air stream.
- 15 28. A cooling system having a fluid cooling heat exchanger including:
- a primary heat exchanger including a closed circuit for circulating fluid;
 - a secondary heat exchanger including a moisture absorbent material that is, in use, maintained moist, the secondary heat exchanger adapted to provide a forced air stream cooled by the action of evaporation in communication with said
 - 20 primary heat exchanger; and
 - a liquid dispenser operable to dispense liquid into the forced air stream.